VAN FLEET (F.)

OPHTHALMIC REPRINTS.

BY

FRANK VAN FLEET, M. D.,

ASSISTANT SURGEON MANHATTAN EYE AND EAR HOSPITAL; INSTRUCTOR IN DISEASES OF THE EYE, NEW YORK POST-GRADUATE MEDICAL SCHOOL.

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THE NORMAL REFRACTION OF THE EYE.

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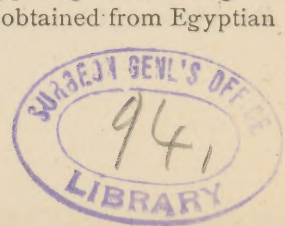
The student of ophthalmology finds very many questions to interest him to-day, and they are all the more interesting because the answers given by different observers are so much at variance. The teacher, therefore, is often at his wit's end to find terse and concise answers which will satisfy the beginner as these conflicting statements are met with and bother and harass his inquiring mind.

Hardly can it be the duty of any man to set straight these crooked and devious ways, but it is the privilege of any one, who cares to take the trouble, to set forth his own opinions and try to untangle the ravel.

Man is essentially a builder of ideals. We try to set up the perfect image and make all else conform to it. And in many instances facts are diverted and twisted until little semblance of the original remains. We get in our mind's eye, so to speak, the road we see mapped out and travel straight ahead, each in his own way, often never looking for the rich fruit that hangs by the wayside.

It is said that an eminent Egyptologist, searching for facts, modified the results he had obtained from Egyptian



monuments, in order that his chronology might not interfere with the received date of the deluge of Noah (Andrew D. White, *Popular Science Monthly*, June, 1890).

Man is a product of nature, and as such subject to nature's laws. Nature does not build rigid angles but rather rounded lines, and so the ideal in nature is rarely found; art is proverbially more perfect.

And so man in his study of the eye has set up the ideal which he calls the normal. Art has constructed an eye which we call the camera obscura, which may be made optically perfect. In many respects a similarity exists between this device of man, this work of art, and the human eye which is the work of nature.

When the camera is in position, its arrangements perfect, as far as its internal parts are concerned, all that remains for the photographer to do is to get his focus. His camera, erected on its tripod, must be moved away from or nearer to the object, as the case may be. If this eye of ours was built entirely on the same plan the same methods might suffice. As we have the camera with its lens and its blackened box set on a moving machine, we might get our focus by stepping backward or forward. But nature has been kinder, and, instead of compelling us constantly to resort to this forward and backward movement, has supplied us with muscular abilities which obviate the necessity, and here the simile between nature and art ceases.

Man has set this optical machine as the model, and as the focus of the lens in the camera coincides with the sensitive plate in the back of the box, so it is said that the normal eye has a focus which exactly coincides with the sensitive plate or retina, and this while the eye is in

a state of absolute rest. Therefore, if the refractive power be the same, all eyes refractively normal must have a certain definite length between the sensitive retinal plate and the anterior surface, the cornea.

This eye is emmetropic, and is accepted as the ideal eye, and while the bold statement is not made in medical books devoted to ophthalmology that this is the normal eye, it is generally understood to be the case.

Donders in his work makes the positive statement, however, that the emmetropic eye is the normal eye. And so we are not surprised that the statement is made that ninety per cent. of all human eyes are abnormal. This, then, is the keynote, ninety per cent. of all human eyes are ametropic. This is certainly a remarkable statement, and yet if we accept the statement that the normal eye is the emmetropic, and if the facts are as stated that the emmetropic eye is one which in a state of absolute rest focuses parallel rays on the retina, then we are forced to admit its truth. We are then brought face to face with the alternative, namely, either man is an anomaly in so far as his eye is concerned, or else the standard is incorrect.

Which is the more likely? In all but this nature has endowed man with organs which, in a state of health, perform their functions normally and are therefore constructed normally. At least this would be the natural deduction. But with the eye, although the vast majority perform their duties normally and are capable of all things for which they were intended, yet—wonderful paradox!—ninety per cent. of them are constructed abnormally. And how do we prove this? By looking through the books devoted to this subject we find, as for

example in Landolt, pages devoted to the proving of this remarkable fact. We prove it with a mass of figures that have been aptly called by Heyl mathematical fiction.

What are the facts? We are taught to recognize three kinds of eyes, namely, the emmetropic, the hypermetropic and the myopic. We recognize still another refractive condition, namely, astigmatism; but while much has been said and written about this condition, and while it causes most of the trouble of which so much has been done in the way of discussion, and which is of all troubles, perhaps, the most amenable to treatment, it is not within the scope of this article to enter into its consideration. So we will lay it tenderly aside for some future time and concern ourselves only with the three grand divisions above mentioned.

For the sake of those who may not be conversant with the meaning of these three terms, and there are such, we will give an explanation of what we understand by the names emmetropia, hypermetropia, and myopia before proceeding further.

By the term emmetropia we mean that the dioptric system with the eye at rest focuses parallel rays of light on the retina—in a state of rest meaning that the accommodative power is absolutely relaxed.

Hypermetropia means that the eye in its antero-posterior axis is too short, and that parallel rays are focused behind the retina.

Myopia means that the same axis is too long, and that the focus is in front of the retina.

And so we have the hypermetropic eye on the one hand, being too short; the myopic on the other, too long, and the emmetropic, the happy medium, and neither too

long nor too short, but just the proper length. Now this implies that the strength of the dioptric system is the same, the eye being in a state of rest. Of course an eye might be of less diameter antero-posteriorly, but if its refractive strength was greater than usual in a state of rest it would still be emmetropic; but as writers of text books give the length of the emmetropic eye as being 22.824 mm., the fact that the lens might be a little more or a little less convex is not considered. And so all eyes less than this are hypermetropic; all more, myopic. The emmetropic eye, therefore, at rest is focused for distance, and for near sight calls into play its accommodative power and still maintains its focus on the retina.

The hypermetropic eye has no focus; for rays from infinity the eye is too short, and as the object viewed approaches the focus is brought still farther back, so that the only way in which this eye can see at all is by constantly making use of its accommodative power, which it does.

The myopic, on the other hand, has a positive point of distinct vision, but it is situated very near. As there is no power of negative accommodation, this eye cannot, by any effort of its own, see clearly distant objects. As this eye is too long, objects must be brought closer, so that the rays which enter the eye may be divergent. So we see that the range of vision in this eye must be very limited. Accommodative power is of little value here, in fact only increases the difficulty, and naturally in these cases we find the muscles concerned in this action illy developed. Quite the reverse from the hypermetropic eye, in which, as would naturally be expected, the muscular apparatus reaches its greatest development.

And yet this weak myopic eye, with its one point of distinct vision, its illy developed muscular apparatus and usual train of unhappy symptoms, is the eye that Landolt would have us believe is the eye of the future—the eye which marks the type of the highest order of development. We, the proud and haughty genus homo, whose mental and physical being is constantly growing and expanding, who in the rapid stride of civilization are giants alongside our ancestors, must in the end have myopic eyes. Alas, the reward is inadequate.

Now, in order that the emmetropic eye can distinctly see objects situated at infinity, it is necessary that the accommodative power be absolutely relaxed. Because if ever so small a part of accommodation be used, the focus would be brought in front of the retina, and instead of a point, circles of diffusion would be formed and the object be blurred. Can the accommodation be absolutely relaxed?

According to Donders absolute relaxation of the accommodation can and does take place, and in describing the action of atropia says there occurs diminution and soon *total* loss of accommodation. And yet at another time he makes the statement, as I understand it, that it is customary for the emmetropic eye under full atropia mydriasis to accept a + glass of scarcely $\frac{1}{60}$. Again, in speaking of the paralyis of the motor oculi nerve, he says it is rarely complete, some, though slight, accommodation still remains.

Donders, in speaking of the connection between the contraction of the pupil and accommodative action, says that there is a direct relation between the two; this we

accept today as without doubt the case. And he says that Listing observes that contraction of the pupil takes place contemporaneously with the will. Again he says that disturbance of accommodation is most distinctly revealed by deviation of the iritic movements.

Now, the action of the iris and ciliary muscle are controlled by the same source of nervous supply, namely, fibres derived from the lenticular ganglion, which receives its motor force from the motor oculi. True, it is said that stimulation of one point of the origin of this nerve will produce contraction of the iris, of another, contraction of the ciliary muscle. But the statement is not made, as far as I know, that the will can be so directed as to cause contraction of the one independent of the other.

Some investigators have claimed to have discovered fibres of dilatation in the iris, as Raettera and Picque, who believe in the active nature of dilatation governed by the sympathetics. Chauveau, Debrerre and others, however, believe that dilatation of the pupil corresponds to a state of rest. It is not even definitely settled that accommodation is entirely due to contraction of the ciliary muscle directly and alone, as Coccius thinks that the tensor choroideæ acts directly on the posterior surface of the lens and thereby changes its form. This being the case, it antagonizes in its action the rest of the muscle. Nor is it certain either that the lens is the only part of the eye concerned in its accommodative power, as we find in Donders the statement that Thomas Young, von Graefe and Jaeger think that some accommodative power remains in the eye after removal of the lens.

Donders himself thinks that in the aphakial eye not

the slightest accommodative power remains. But he qualifies this by saying that if any remain it is less than $\frac{1}{100}$, which may be considered as nothing. Be that as it may, certainly if any remain, be it ever so small, it proves the existence of a power situate in some other part. In Sajous' *Annual* of 1889, we find this quotation from Heyl: "When one is walking along the street with the mind absorbed in thought, the macula of each eye is pointing at one point in space. In this there is no conscious exercise of the will." This is in accordance with my own observation. In this condition we may see objects before and around us but we do not recognize them. But when we desire to gain distinct vision we make an effort. We bring to bear on the object our visual lines, and there is an exhibition of will. Now, with this exhibition of will there occurs contraction of the pupil. Who shall say that there is not some accommodative power brought into play at the same instant? Inasmuch as Donders says that the emmetropic eye under full atropine paralysis will accept a weak convex glass, it is probably true that there is. Obviously, then, this eye, is not emmetropic, or if it be emmetropic now, it wasn't before. If it focuses now, under influence of the will, parallel rays on the retina, the same rays in the relaxed condition of the eye would have been focused behind the retina. This eye, therefore, must be hypermetropic. And so I make the statement, from the foregoing analysis, that the eye which under the influence of the will, which is a necessary accompaniment to distinct vision, focuses parallel rays on the retina must be hypermetropic, and that all other eyes are myopic. Arminski says that the hypermetropic eye is the normal refractive condition in the un-

civilized man. But he might have included in this statement the whole human race, civilized and uncivilized.

This hypermetropic eye, too, is the eye which abounds in nature. Jaeger made the statement that the eye at birth was myopic. Ely was, perhaps, the first to disprove this, although at almost the same time, or shortly after, many other observers placed their proof in the field that the eye at birth is hypermetropic.

Ely examined 111 children, only six of whom were over two months old. He made satisfactory examinations in 90 children and 154 eyes. His method was as follows: He first paralyzed his own accommodation with atropia. He did the same to the eyes of the children. He also gave each child an anodyne in the form of paregoric, which would seem a very necessary proceeding. Then with the aid of a Loring ophthalmoscope and an assistant who held the child's eye open, he conducted his observations. He found hypermetropia in seventy-two per cent., myopia in eleven per cent., and emmetropia in seventeen per cent.

Jaeger used no atropia, which may account for his error, as Ely found in 49 eyes where he didn't use atropia a much higher percentage of myopia. But in the cases in which he did use atropia, it is quite likely, as atropia does not entirely relax the accommodation, that all those put down as emmetropic were really hypermetropic, and we can safely say that hypermetropia exists in at least ninety per cent. of all human eyes at birth.

Nor are we compelled to depend upon Ely's finding alone. Risley in 2,422 eyes found hypermetropia in seventy-four per cent., myopia in eleven per cent., and emmetropia in thirteen per cent. in school children rang-

ing from eight to seventeen years of age. And if the emmetropic eye is really hypermetropic, then eighty-seven per cent. of these children were hypermetropic.

Hansen, in 1884, found 94.4 per cent. hypermetropic in 805 children. Many others have likewise published the same results.

Hypermetropia, thererore, is the normal condition and the only condition which is consistent with clear and distinct distant vision. That the majority of the human race have this is, I think, true without doubt.

Dr. Herndon, Surgeon United States Navy at the recruiting office in this city, informs me that less than five per cent. of all applicants at his office have vision less than $\frac{20}{20}$. And so, as most of the human race have distinct distant vision, and as such vision can only be obtained by the hypermetropic eye, and as it was doubtless intended that this was the form of eye which should be part of the human race, we feel justified in saying that the hypermetropic eye is the normal eye, and while it might hardly be true to put it at ninety per cent., it is at least safe to say that the large majority of human eyes are refractively normal.

Leaving out of this discussion, as I said above, the presence of astigmatism, we have, then, two grand divisions into which we ought to divide the refractive condition of the eye, namely, the hypermetropic or the normal, the myopic or the abnormal.

Emmetropia, in the ordinary acceptance, does not exist, except as the beginning of myopia.

As Arminski says, myopia is the product of civilization developed in the struggle for existence. Emmetropia is only a stage of transition to myopia.

THE DETERMINATION OF THE REFRACTION OF THE EYE WITHOUT A MYDRIATIC.

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Science progresses just in proportion as the race becomes enlightened. The more intelligent the people, or, more properly speaking, the investigators who represent the people, the more rapid will be the strides onward and upward. Again, we can argue in the other direction, and so connect the two ends and make the circle complete. The more advanced the science the more intelligent will the people be, and therefore the investigators, and the more rapid the strides. So we may say progress and intelligence walk hand in hand and are indeed inseparable. The presence of one necessitates the other. Some must of necessity remain outside the circle who cling to old and generally discarded notions, either from inability to grasp the new or because of a natural and praiseworthy dislike for turning a cold shoulder to a tried and trusted friend. But turning to new methods does not necessarily mean treason to the old. We can still think of them with grateful remembrance, and, indeed, hold them in reserve because they are old and trustworthy, and when the new fails us, as all things human may, we still have something to fall back on.

But the world revolves and science progresses, and if we would keep in the grand procession, we, too, must move on nor tarry by the wayside, for time and tide wait for no man. Ruts may be comfortable for a time, but he who continues in them as time passes will eventually become lonesome. It will not do either to take up

with every new thing that comes along and say, "this is the thing." Give every sensible arrival a cordial welcome. It is not necessary that every arrival should be welcomed with outstretched arms and the fatted calf killed and a feast prepared, neither is it just that a cold, forbidding aspect should be presented and an effort made to freeze him out. Give to all a cordial welcome, and if time proves the merits of the case, then the newly arrived has come to stay and is welcome. If not, then the death will be a natural one and our hands will be clean.

Ophthalmology has not been behind in the progress of time. In the past thirty years much has been done in in the way of improvement. Much is being done all the time. Ideas are being evolved from day to day, and truths are being made more patent. We take more common sense, practical views today than yesterday, tomorrow will be an improvement on today; and who can tell but that in the future the man who today is curing a diseased eye by irritating the sole of the foot, may be doing something still more wonderful?

Our knowledge of the refraction of the eye is not, perhaps, what we should like to have it. And to me it seems that the reason is because the groundwork is not well laid. Before we begin to concern ourselves about the errors, we ought first to have a settled, definite idea as to what constitutes the normal. We have done very much in this respect, but the early investigators made the mistake of figuring too exclusively on a mathematical basis. Man is not a mathematical machine in any sense. And as other parts of his body are considered from a standpoint of anatomical formation and physiological function, so ought the eye to be.

But people come to us with errors which they desire corrected, and we must know how to correct them. Now, my object is to discuss, not how this is to be done, but how to ascertain how an error, if it exist, can be discovered with the means we have at hand. Beginning, therefore, with the parts concerned in refraction, we come first to the cornea. This delicate, transparent structure, in order to refract light properly, so as to bring rays to a focus, which will be a point, must have an even curved surface which shall be the same in all meridians. And so, normally, we expect to find it. Often we do not find it so. Although the surface may be smooth, no facets or opacities, the result of old inflammatory trouble, marring its contour, yet we find, because of some reason to us unknown, it has different radii of curvature in different meridians. It may be more curved, for instance, horizontally than vertically. This we call astigmatism, the amount being the difference in curvature. This, so far as we know, is an accident of birth, perhaps a congenital malformation. The one peculiar feature of such a condition is that the meridians of least and greatest curvature are, in the majority of cases, at right angles to each other. Many theories could be advanced on this one feature alone, which, however, would not be appropriate here. What means have we now for discovering this condition? The patient's statement might of itself disclose it, and very likely would if the error were great. The test types of Green or Pray would be to us a valuable aid as well, if no ontagonizing element existed overcoming the astigmatism. The ciliary muscle and lens, however, in cases where the error is slight, overcomes it so perfectly that we would be left in the dark unless we resorted to

some paralyzing agent or mydriatic to aid us. The acceptance of a cylinder as an indication of the existence of astigmatism is very misleading. Patients suffering from small errors find it very difficult to say just when they do or do not accept a glass. Mydriatics of course will overcome this condition, but mydriatics, besides subjecting the patient to inconvenience and annoyance, often produce symptoms as disagreeable to the patient as was the asthenopia before complained of; as I have heard people say, "the cure is worse than the disease." Besides this, we occasionally find people who resist even the strongest mydriatics. If mydriatics must be used, atropia is really the only one which is deserving of consideration; duboisia and others, on the one hand, being more dangerous; homatropia, on the other, according to the best authority, being very inefficient. Retinoscopy is valuable, but open to the same objection that we find in the case of the test type and the trial case. With a mydriatic we would do fairly well, but without it the ciliary muscle plays a greater part than the real structure concerned. Ophthalmoscopy give us, grossly, a very good idea of what the refraction may be in a given case. But the ophthalmoscope, invaluable as it is in the hands of the ophthalmologist, is still in his hands; and as the grasp of his hand may be stronger or weaker today, so may any or all of his muscles, including the ciliary. And as variation on his part may occur, so may it on the patient's part, and we have two human beings taking part in an observation and basing the result on the unknown quantity, muscular action. The best observers ophthalmology has ever had were and are unwilling to express an opinion on slight errors as depicted with the ophthalmoscope.

Beginners often give forth the ultimatum as the result of ophthalmoscopic examination; skilled ophthalmologists never.

And so, having considered test types, trial cases, retinoscopy and ophthalmoscopy, what have we left? That wonder of the age, the ophthalmometer. Here we have an instrument of precision, uncontrolled by varying function or conflicting elements; depicting to us as absolutely and certainly the existence or non existence of corneal astigmatism—which mydriatics and experience have shown us is the only astigmatism with which we have normally to deal—as the needle the pole; not only this, but also whether our astigmatism is regular or irregular. It gives us the axis truer than the patient's muscle, and indicates the position of the cylinder which will correct it. Thousands of cases bear proof of this statement.

Having, then, indicated how the existence of astigmatism may be detected without the use of mydriatics,, we pass backward to the next structure concerned in the refraction of the eye—the crystaline lens. This biconvex body, controlled by the ciliary muscles, exercises its most important function as the organ of accommodation, possessing a power equal, as a rule, to a convex spherical lens of 11D. Its absence could be easily supplied as regards its position in the normal refraction of the eye in a state of rest. As an accommodative organ its place could never be filled by any force at present known. A mydriatic would seldom be necessary to bring out its true reractive status as a matter of general practice. Contracion of its regulator, the ciliary muscles, enables it to overcome astigmatism and hypermetropia, or, on the other hand, increases a given case of myopia. The exhibition

of a mydriatic would seldom, if ever, be necessary to enable us to determine the existence of myopia, as the ophthalmoscope would enable us to accomplish this without difficulty; and likewise with hypermetropia, as we might be certain that if myopia did not exist hypermetropia did.

And so the necessity for using a paralyzing agent in determining the refractive status of the eye becomes daily less and less. True, spasm of accommodation may convert simple hypermetropic astigmatism into simple myopic astigmatism, or even into mixed astigmatism; mydriatics would demonstrate the true condition of affairs, but the ophthalmoscope would give us the gross facts as well. But it may be said: Although your ophthalmoscope may determine the kind, it will not compel the acceptance of the suitable glass; atropine will. True, after the lapse of time—a week or perhaps more—it may. But the glass indicated by the combined examination of ophthalmometer and ophthalmoscope, if worn for the same length of time, would accomplish the same result, and that, too, without the loss of accommodative power. But you say: How about other conditions than astigmatism? Difficulty in determining the refractive condition does not exist in hypermetropia and myopia; mydriatics will not assist us here a particle, the ophthalmoscope being all-sufficient. With astigmatism the same cannot be said. Here, if we are limited in our means for properly examining the eye, we must perforce, at times, resort to mydriatics; but possessed of an ophthalmometer, the necessity for mydriatics in the determination of the refraction of the eye is becoming a thing of the past. The new arrival has been tried and proven. It has come to stay.

ERRORS OF REFRACTION.

Read before the Post Graduate Clinical Society, April 2, 1892.

Of all conditions of the eye, the one which engages the attention of student and teacher alike, more than any other, is that known as the refractive.

And why? All other conditions peculiar to this organ are not different from conditions in other parts attacking similar structures. For example, a conjunctivitis may be treated in a manner similar to inflammation attacking mucous membranes elsewhere. And so with vascular derangements, tumors, and so on. The treatment of cataract surgically does not differ from the same rules we would apply to surgery generally. Antiseptic, hygienic, and all treatment we may be called upon to display here can be accomplished by making use of the general rules applicable to the surgical and medical treatment of other organs But with the refraction of the eye we have a condition peculiar in itself—as has been remarked, a condition which is, to the man interested solely in general medicine, a thing mysterious. The terms made use of to express certain conditions, as hypermetropia, myopia, emmetropia, etc., while conveying a definite meaning to the mind versed in ophthalmological lore, convey to the uninitiated no significance whatsoever.

Talk of myopia to the specialist in other departments, and he gazes at you with a look of profound amazement. The inky hue of darkest Africa seems not more opaque to his mind than the subject under discussion. Now mark me, I do not mean any disrespect to the gynæcolo-

gist, rhinologist and others; but the subject of ophthalmology is so connected, in the minds of those who have not made it a special study, with intricate problems of algebraic equation, that the majority of our medical brethren have come to look on it as a thing to be left to the oculist alone. Fortunate it may be for the oculist, and better, perhaps, would it be for the general public, if there were no exceptions to this rule. The student accordingly comes to us looking on a successful and noted member of our specialty as one necessarily well versed in mathematics. And this view acts often as a hindrance to his acquiring the knowledge he might were it otherwise. We find, it is true, many works on the eye which enter deeply into theoretical ophthalmology, but these generally exhibit a lamentable dearth of common sense facts.

I would not have any one think that I mean to argue that a knowledge of the optical laws is not necessary to every oculist who would thoroughly understand his subject. Not at all. But I will say that if there were less theory and more practical application of the facts as they exist, it would be better for all concerned

It is said of a world renowned investigator and propounder of evolution that he generally wound up his arguments and writings by proving just those things he had started out to disprove, not only to his hearers and readers, but also to himself. I am sometimes fearful lest the same may be said of me. I have always been a deprecator of theories, and in my lectures in this School, and also in my feeble efforts, both here and in papers I have taken the liberty of writing on this subject, I have endeavored to inculcate common sense doctrine in their place. How illy I have succeeded was never more

patent to me than when, on meeting recently a former student, almost his first greeting was, "How are you getting along with your theories?" Still, although there will always be found those who will misunderstand and misinterpret, nothing daunted, I have made bold to present to this Society some thoughts which have occurred to me in my studies of the beautiful subject of the refraction of the eye.

Errors of refraction—what are they? Errors are departures from the original or the normal. The possibility of the existence of an error must therefore imply that there is a normal.

A glance through the text books discloses to us that there is a recognized normal refraction of the eye. But it is so mixed and jumbled with conditions that are not refractive that one is forced to conclude that, if there is a normal refraction, it is purely imaginary.

Now, what constitutes the refractive apparatus of the eye, or, as it is called, the dioptric system? To go back to the original optical laws, it is sufficient to say that rays of light passing from one medium to another of different density are bent or refracted—that is, they are deviated from their original course, and rays passing through the eye are acted on by the positive refractive quality of the dioptric system, and are brought to a focus.

We are taught that this focus is a fixed point—that is, while the eye is in a state of rest, its accommodation relaxed. And in considering the subject matter in hand, we need not concern ourselves with the accommodation.

If, therefore, we take the refractive power of the

crystalline lens as equaling 11 D., and the retina situated at 22.8 millimetres from the cornea, we have the difference made up by the cornea, aqueous and vitreous. That is to say, reducing the lens of 11 D. to inches, a focal distance of $3\frac{1}{2}$ inches is obtained. We therefore have the difference between 22.8 millimetres, or about seven-eighths of an inch, and the focal distance of the lens, or $3\frac{1}{2}$ inches, made up by the other factors which go to make up the refractive apparatus, or a difference of $2\frac{5}{8}$ inches.

Taking this as our standard, we give it the name of emmetropia. We have as deviations from this standard the two conditions known as hypermetropia and myopia —in the first instance the retina being in advance of the focal point; in the second, behind it.

This deviation applies, not to diminution or increase of the refractive power, but entirely to the position of the receptive organ, the retina. As proof of this we cite Helmholtz, Donders, and a host of others whom we might call the fathers of ophthalmological science. Following them are those who have continued their labors, and who have recorded their views in the books that teach us all we know, or at least the fundemental principles. By referring to almost any work on the subject we can tell just how much the eye is shortened or lengthened in a given case. For instance, a hypermetropia of 3.50 D. will indicate a shortening of 1.06 millimetres; a myopia of 3.50 D. a lengthening of 1.19 millimetres.

I do not wish to pose as a champion of these views, although they are probably based on actual examination and measurement in thousands of cases; nor do I presume to discredit them. I merely present them as I

understand them, as stated by the recognized authorities. But this I do say and desire to emphasize: that if they are true, and if hypermetropia and myopia are due to shortening or lengthening of the optic axis, by which we mean the antero-posterior diameter of the eye, then they are in nowise errors of refraction, and that the refraction of the eye has nothing to do with it. If the emmetropic eye is the normal, hypermetropia indicates a lack of development, and myopia a hyperdevelopment, as is claimed by Landolt. And if this is the case, it is a most remarkable thing that this lack and increase of development should be confined to the tunics of the eye and affect no other part of it. But I am convinced that this is not the case. Hypermetropia is the ordinary condition. Myopia is a deviation, but not an error of refraction. It is a deviation from health, in fact a disease, and emmetropia is merely its beginning. Not only is myopia a disease, but one a predisposition to which we transmit to your progeny as absolutely and surely as other diseases, unless some neutralizing agent is brought into play to combat it.

But, admitting for the sake of argument that the length of the eye should be 22.8 millimetres, and that this coincides with the focal length of the dioptric system, and that hypermetropia and myopia are errors of development and not errors of refraction, the question arises, *are* there any errors of refraction, and, if so, *what* are they?

Following out my line of reasoning, it must be very evident that errors of refraction are those affecting the refractive organ itself, grouping the different media as one body.

Now, what are they? We would consider any deviation in the contour of the refractive body, which would make the focus anything else than a point, as an error. For example: if the refractive power be greater in one meridian than another, and if instead of having one principal focus we have two foci, one anterior to the other, we would have an elongated image instead of a point. Indeed, we might have any number of foci, if we consider marked irregularities such as occur as the result of disease. Then we have errors due to opacities of the cornea, lens, or vitreous. Deviation from the normal will occur also from conical cornea and a host of other conditions, due to disease or weakness in the different media, either acquired or congenital. But these are exceptional and might be called abnormal; and as the books mention normal astigmatism, I feel that I am not going outside the possible when I speak of the condition in this way, and divide my idea of errors of refraction into normal and abnormal, or, what would perhaps be better, remedial and irremedial.

Therefore we will say we have errors due to disease, errors due to perverted muscular action, constituting spasm of accommodation which is secondary and temporary, and errors due to senile change or presbyopia. Eliminating these conditions, we have left then the condition known as corneal astagmatism, which, besides being the only error we are called upon to correct by means of glasses, is, according to Professor Roosa, in the *Medical Record* of March 26, 1892, the condition most often productive of what we call asthenopia. In the same periodical, under date of December 5, 1891, I had the honor of presenting an article on the normal refraction of the eye,

a brief summary of which is as follows: Hypermetropia is the normal condition. Myopia is the exception. Emmetropia is only a stage of transition to myopia. I do not, however, propose to reargue this proposition. My subject tonight is errors of refraction, and my brief is handed in, and the inferences to be drawn are these:

1. The refraction of the eye is due to rays of light passing through the dioptric system.

2. Errors of refraction must be due to some obstruction to, or deviation in the ordinary passage of rays of light through this system.

3. Hypermetropia and myopia are terms applied to the length of the optic axis. They have nothing to do with the refraction of the eye directly, according to the accepted authorities, and cannot in any respect be considered errors of refraction.

4. Eliminating errors due to obstruction, errors due to muscular spasm, and errors due to senile changes and disease, the only error of refraction which is permanent and due to alteration in the curvature of the refractive media is corneal astigmatism.

And, furthermore, the general facts I wish to emphasize are these:

1. There is no subject in medicine more confusing and mysterious to the beginner than the refraction of the eye.

2. There is no subject in medicine more perfectly understood than is the refraction of the eye by the practical ophthalmologist.

3. That ophthalmology would be robbed of its mystery if the knowledge we possess were placed in a more matter of fact, common sense form.

ASTIGMATISM: ITS LOCATION AND DETECTION.

A Clinical Lecture Delivered at the New York Post-Graduate Medical School.

Reprinted from *The New York Medical Journal*, July 9, 1892.

I present to you for consideration this morning Mamie J., who was referred to us for examination from the department of nervous diseases, with the following history: Patient has always had convulsions. When three years of age she fell from a window and sustained a fracture of the skull. She was trephined in the left parietal region, the hole of which you can now feel. Patient has had epileptic seizures ever since, both *petit* and *grand mal*. She also has hemiplegia of the right side. Our examination reveals the following: Patient is well nourished. This is important. One's general muscular development is an important factor in overcoming refractive error. The expression of the face is not intelligent—in fact, is rather stupid. Another point to be borne in mind: People with refractive errors which they are unable to overcome, or which they overcome only with the greatest difficulty, are apt to be below the average in intelligence. This is a rule to which there are some striking exceptions, but as a rule it holds good, and is an important fact, and one we should never lose sight of, as it has a most important bearing on the education of the young.

The patient's face otherwise looks normal, and there

is nothing to call especial attention to her eyes except the fact that she is wearing glasses.

We will first of all see what they are. Moving them in front of our eyes, we find that objects viewed through them seem to move in a direction opposite to that in which the glasses move. This tells us that we have a convex lens. And as the object seems to move equally in all directions, we know that we have a spherical lens. We find that a spherical concave of 2 D. exactly neutralizes it. Therefore this patient is wearing a convex 2 D. spherical before each eye.

This would indicate that she is hypermetropic, because, as you know, the acceptance of a convex glass for distant vision is only possible with hypermetropia. If we remove the glasses we notice immediately that she has a peculiar feature, suggestive of myopia, because it is a habit myopes have, and from which the name itself is derived. I refer to the nipping of the eyelids, or narrowing of the palpebral orifice.

We find in consequence of this that the patient's visual field is narrowed, which is not the case when her eyelids are opened wide.

Let us now proceed to our examination as we would in any ordinary case. We will now go over the ground together, and afterward discuss the result.

First, the ophthalmometer. You have all been taught how to use this wonderful instrument, and it is not necessary that we should here enter into any explanation of it.

We find the mire lines horizontally, giving us our primary axis. We expect, therefore, to find any astigmatism that may exist by turning the bar 90° from this point. Turning to the right, we find with the bar vertical

that the mires still line and overlap in the right eye one step and a half, giving us 1.50 D. astigmatism with the rule.

In the left eye we find also astigmatism with the rule, but overlapping two steps, indicating 2 D.

This indicates that between the two meridians there is a difference of 1.50 D. in the right eye and 2 D. in the left.

Being with the rule, we know that the meridian of greatest refraction is vertical and is to be corrected by a plus cylinder at 90° or a minus cylinder at 180°.

This much accomplished, we make use of our ophthalmoscope to determine whether this is hypermetropic or myopic astigmatism. If we employ retinoscopy, we find, with the concave mirror, that the shadow moves against the glass in all directions. This implies that we have hypermetropia. Approaching the eye, we find that the strongest convex lens with which we can clearly see the details of the fundus is + 4 D. in the right eye and + 5 D. in the left. Therefore we have a case of compound hypermetropic astigmatism. Seating the patient now at twenty feet from the test type, we find that she has in the right eye V. = $\frac{20}{40}$, and with + 1 D. c., axis 90°, V. = $\frac{20}{30}$ +.

Left eye V. = $\frac{20}{70}$, and with + 1.50 D. c., axis 90°, V. = $\frac{20}{30}$ +. Convex spherical lenses do not improve. The question as to whether I ought to give her spherical glasses in addition to the cylinders I shall leave to some future time to decide. I shall say in this connection only that at her age, which is seventeen years, with good ciliary muscles and her astigmatism corrected, she may be able to get along with cylinders alone. At any rate,

I shall correct her astigmatism only for the present, and we will keep her under observation and note the result. In this connection I would refer you to a paper lately published by Dr. Roosa on this very subject.*

Nor do I propose to enter into consideration of her error of refraction being a possible cause of a reflex neurosis. That we will leave to the nervous department, having the knowledge that if it is the cause of her nervous condition, we have put her in the best possible condition to derive whatever benefit may be possible to her.

I want you to especially observe and remember the great facility with which we now accurately fit this class of patients with the instruments of precision we have at our command, and to impress on you the necessity of you supplying yourselves with an ophthalmometer and of using it intelligently.

The value of this instrument, in my mind, is dependent on two things: First, the seat of the trouble, and, second, the accuracy with which we determine its exact nature.

Let us consider, therefore, these points in the order in which I shall state them. What is astigmatism, where is it located, and what are the forces which tend to overcome it? Astigmatism means that the refraction of the eye is not the same in all its meridians. We recognize two kinds—regular and irregular. By regular astigmatism we mean that we have two meridians the foci of which are different, and instead of having on the retina a focal point, we have a line. These two meridians are usually perpendicular to each other, and their foci are cap-

**Medical Record*, March 26, 1892.

able of being brought together either by forces situated in the eye itself, or by lenses placed in front of it.

Irregular astigmatism implies that instead of two meridians we may have any number, by which rays of light are so broken and twisted that it is impossible, by any known means, to bring them together, and is therefore capable of very little if any improvement. This condition is the result of disease and we can do very little for it. It can, however, as a rule, be easily detected, both with the ophthalmoscope and ophthalmometer, and need never be mistaken.

Regular astigmatism has to do with the refractive apparatus of the eye. Those of you who honored me with your presence when I read my paper on errors of refraction know how I would classify regular astigmatism. For the benefit of those who were not present, I will state my conclusions briefly as follow:

Hypermetropia and myopia are due to variation in the length of the optic axis and cannot with justice be called errors of refraction. Astigmatism is conceded to be due to error in the refractive apparatus, meaning the cornea or lens, and is the only error of refraction that can be justly called by that name.* Astigmatism, therefore, being truly an error of refraction, must have its seat in the refractive body, and we are narrowed down, for obvious reasons, to the consideration of the crystalline lens and the cornea.

Astigmatism could not be due to the aqueous or vitreous humors for purely physical reasons. And I am convinced that primary astigmatism of the crystalline lens is equally impossible.

**Post Graduate*, June, 1892.

In a letter of mine published in a medical journal of a neighboring city, the editor accused me of making gross and glaring misstatements. I have forgotten the exact language, and without any very definite reasons, or at least if he had any he failed to state them, arbitrarily refused to discuss the question with me further. Whether he felt the weakness of his ground or considered me too small a game I am unable to say*. At any rate, I shall not follow in his footsteps, but will endeavor to prove to you why, in my opinion, primary astigmatism of the lens is impossible. In discussing this subject it will be necessary to consider the lens in a state of rest and accommodation, and the forces which control it.

The crystalline lens is a biconvex body situated behind the iris, with the pupillary border of which it is in contact. In front of the lens beside the iris is the aqueous humor, which, being a fluid, exerts an equal pressure on all parts of it. Behind the lens is the vitreous humor, which, being semi-fluid or gelatinous inconsistency, exerts also an equal pressure in all directions. The lens is suspended between these two media by the ciliary body through the intervention of the suspensory ligament, the zone of Zinn.

The structure of this zonular ligament is still a matter of doubt. It is described as composed of tough fibres which spring from the vitreous body, of which they are a part. They seem to start from the region of the ora serrata, passing forward to the most anterior part of the ciliary body, from which they are bent inward and pass to the anterior and posterior portions of the lense capsule. They are supposed by some authors to contain

* *Medical News*, April 23, 1892.

muscular fibres, and when divided the severed ends appear wavy, like elastic tissue.* Or, again, it is described as composed of an agglomeration of fibres having the nature of connective tissue.‡

It would seem, in studying the mechanism of accommodation, as if there must be some elasticity present to account for the changes that take place.

The ciliary muscle has its origin from the sclero-corneal juncture or in that region, and extends backward in a fan-shape. Its outline is pyramidal, having its apex backward,† or, as said by some, having its apex at its point of origin.§

Having this structure, the action of accommodation is simple. The contraction of the ciliary muscle draws its point of attachment toward its origin. The origin being at the sclero-corneal juncture, and the attachment into the ciliary body and choroid, some fibers, in fact, going back to the opic nerve entrance,‖ the whole interior of the eye is drawn forward. The choroid and retina come forward, the ciliary processes are drawn together and thickened. The whole peripheral insertion of the zonular ligament is drawn toward the lens. In consequence of this, the tension exerted on the lens is relaxed, and it becomes more convex through its own elasticity. Relaxation of the ciliary muscle causes the reverse of this action. But while the action of the ciliary muscle in

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* *Lectures on the Human Eye*, by Adolph Alt. M. D.

‡ Landolt. *Refraction and Accomodation of the Eye.*

† *Ibid.*

§ Noyes. *Diseases of the Eye.*

‖ *Ibid.*

accommodation denotes force and exertion, relaxation is passive and denotes no power.

If the lens, through its own elasticity, can become more convex, simple muscular relaxation, which is purely a passive movement, could not of itself overcome it. If there is elasticity in the zonular ligament, then, as it springs back into place when released by the muscle, a struggle must take place between it and the lens for supremacy.

But the ligament is re-enforced by another factor which is the tension of the eye. Neither the ligament nor the tension is sufficient in itself to overcome the elasticity of the lens, but the combined action of the two accomplishes the purpose. Again, the amount of tension of the eye is not constant. Neither is the power of accommodation constant. And this, it seems to me, is not entirely due to the ciliary muscle. Anything which will increase or diminish the tension will materially affect the power of accommodation.

This is shown by the occurrence of presbyopia, where, besides the lens losing its elasticity through hardening of its structure, increase in intra-ocular tension generally occurs. I think it is an accepted fact that tension of the eye is increased with advancing age.

Again, a most striking example of the effect of tension of the eye on the power of accommodation is shown by the occurrence of glaucoma, one of the earliest symptoms of which is loss of accommodation and recession of the near point.

So if the tension of the eye exerts a power in overcoming accommodation, and if that tension is equally distributed over the anterior and posterior surfaces of the

lens, we can easily see how impossible it is for that body to assume any irregularity in its outline while in a normal condition as regards consistency.

If the tension of the zonular ligament is relaxed in any one part, as it is possible might happen through irregular muscular action, we can see how lenticular astigmatism might occur.

But irregular muscular action does not take place except from some definite cause. If the refractive media are not the same in all meridians, then the effort of Nature to compensate might, and does, produce irregular muscular action. Irregularity cannot exist in the aqueous or vitreous humors except as the result of disease. But it can, and does, exist in the cornea; and lenticular astigmatism when it exists, other than as the result of cataract or disease of other kind, is invariably the effort of Nature to overcome corneal astigmatism, and is purely reflex and secondary. It always occurs when a person with corneal astigmatism has perfect vision.

How shall we then detect corneal astigmatism?

I have told you so often that you may have come to think it tiresome that the ophthalmoscope and retinoscopy will give you the gross facts. But very few oculists would be content to prescribe glasses on their findings alone. Atropine will give the facts fairly well, and, I think, in the majority of cases, accurately. I say in the majority of cases, because there are times when atropine fails totally. And if you rely on it alone, some patients will go improperly fitted, as witness the case of Dr. T., one of our students.

The doctor complains of constant headache, and is unable to work. He has been wearing —0.50 D.s., given

him after a course of atropine. The ophthalmoscope shows him to be hypermetropic, but he absolutely refuses plus glasses The ophthalmometer shows him to have 1 D. astigmatism with the rule axis 90°. He has worn the cylinder indicated now for nearly a month with perfect relief.

His case is not an exception by any means. I could show you a great many histories of like cases in my case-book.

Again, if you find the astigmatism under atropine, you cannot always be certain about the axis. In a paper read before the American Medical Association last year, by Dr. G. M. Gould, of Philadelphia, the failure of atropine in some cases is expressly shown.* With the ophthalmometer, however, we can tell absolutely and certainly the presence or absence of astigmatism. The meridians of greatest and least refraction and their axes are pointed out to us as absolutely and certainly as anything ever can be.

Atropine is a most valuable agent in the treatment of certain diseased conditions of the eye, but for the determination of errors of refraction it is not only uncertain and often misleading, but absolutely unnecessary.

Some individuals will always be found who, with perhaps admirable, but nevertheless unfortunate, pertinacity, will cling to a lost cause as long as life remains; but to you, if you desire to place yourselves on an equal footing with the ophthalmologists of today, my advice is get an ophthalmometer and use it intelligently.

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* *Journal of the American Medical Association*, Vol. XVII, No. 12

Reprinted from *Medical News*, April 23, 1892.

To the Editor of *The Medical News*.—Sir: In an article appearing in your journal of April 2, taken from *The Therapeutic Gazette* of March 5, some statements are made that seem to me to hardly express the true position of our science today, in the relative value of the different methods employed in the estimation of refractive errors.

However assured we may feel of the superiority of our methods over those of our neighbors, we ought to feel our way carefully. I am so often reminded of the question once put to me, when giving testimony of an expert character, by the counsel of the opposite side: "Doctor, is medicine an exact science?" Medicine will be exact just in accordance with the exactness of its investigators and the measures they employ. And it seems to me that we ought not to be too hasty in either our support or condemnation.

In estimating refractive errors the value of the measure employed will depend upon the seat of error.

True astigmatism, by which I mean actual and permanent alteration in the curvature of the refractive body, is pretty generally conceded, I think, to have its situation in the cornea. True, it may occur in the effort of nature to overcome the real trouble, and so give us lenticular astigmatism. Lenticular astigmatism must always occur when nature succeeds in overcoming corneal astigmatism. But the secondary error is seldom, if ever, permanent. If it were, astigmatism would be a cause of asthenopia far less often than it is. Mydriatics are only necessary in this class of cases to relieve the secondary muscular effort. And as this effort is maintained only by

the utmost strain, the muscle will readily relax when relieved by the proper glass.

Time was when mydriatics were necessary to tell us the proper glass and its axis, but since the introduction of the ophthalmometor of Javal and Schiotz, we have a means of estimating these more accurately and rapidly than we have ever had before.

True, there may be cases in which we may be compelled to resort to mydriatics, as in cases of persistent spasm of accommodation, and in some cases of mixed astigmatism. But, as we all know, even mydriatics may fail us here. We do not speak from a theoretic standpoint, for in our clinics at the New York Post Graduate School, and in the Manhattan Eye and Ear Hospital we have proof of what we say in cases almost without number. Nor do we speak from a desire to fight merely for the sake of fighting, but because of a genuine love for our science, and a desire to elevate and advance it.

The value of retinoscopy, I have always maintained, was depreciated by the fact that lenticular astigmatism endeavors to overcome the error. The ophthalmometer simply tells us that we have corneal astigmatism, its amount and axis, and experience has taught us that we can rely on its finding. We have to resort to the ophthalmoscope to tell us the kind. Mydriatics may perhaps be very acceptable to us when we are in doubt. Even Dr. Roosa, who is enthusiastic on the subject, will, I think, admit this.

My views were put forth in the March number of the *Post Graduate*, to which I beg to refer you.

I feel, Mr. Editor, that the article quoted in your able journal does not properly define our position. We

do not entirely disregard mydriatics in toto. It is possible we may come to that, but, after a reasonable trial, we feel justified in saying that, given an ophthalmometer and an ophthalmoscope, in the vast majority of cases mydriatics are unnecessary in estimating errors of refraction. Very truly yours,

Frank Van Fleet.

Reprinted from *The Post Graduate Medical Journal*, May, 1892.

April 2, 1892.

Dear Mr. Editor.—There appeared in *The New York Medical Record*, under date of April 2, 1892, an editorial entitled "Treatment of Myopia Without Glasses," which presents such a gross misinterpretation of the facts as they exist, as in my opinion to call for a protest.

We do not expect, of course, that the editor of a journal should be conversant with all the discoveries made in every specialty. It is as much as any one man can accomplish to keep himself posted in the advances made in his own particular line. Life is too short, and the demands are too great to expect anything else. But it is not too much to expect that a writer will either be familiar with the facts and present them in their true light, or else leave them severely alone. Now let us consider this editorial, taking seriatim the different statements made, and consider their value.

The tendency of oculists to prescribe glasses for muscular refractive troubles of the eye is apparently increasing. Many recommend glasses for slight insufficiencies of the ocular muscles. Still more advise glasses for slight degrees of hypermetropia and astigmatism. The number of spectacled children is nowadays enormous and is yearly increasing.

This we are very willing and glad to admit. We wish the number and increase were even greater. Very few oculists prescribe glasses for slight amounts of hypermetropia. If hypermetropia required glasses, then nearly the entire race would require them; for we all, with few exceptions, are hypermetropic, and those who are not are unfortunate. The point to be considered

here is this: It is not the hypermetropia, but the weakened or illy-developed ciliary muscles that require relief. This is one of the facts that the coming years will demonstrate beyond peradventure. True, if this class of cases could be given the proper life and hygienic surroundings, and the general tone of life be elevated, glasses could often be dispensed with. But, unfortunately, for obvious reasons, this often cannot be done.

The same argument will be applicable to slight amounts of astigmatism. But here we have a different condition. Hypermetropia is not an error of refraction and never of itself requires glasses. Astigmatism is an error, and due to a want of symmetry in the cornea. Such a condition requires for its correction irregular muscular action, which is entirely different from hypermetropia. But even in astigmatism the same statement applies, although of course in a modified form.

Let us consider the next statement, which I think requires very little in the way of discussion.

> We are not prepared to deny that glasses thus prescribed are not needed, or that the patients are not always benefited by them. Yet it seems as if, possibly, the thing were a little overdone. The patients are, perhaps, in a measure to blame, for few who go to the oculist for weak or defective vision are quite satisfied if they do not get a prescription for glasses at least.

I think it may be safely left to the oculist to do here what the conditions existing call for. The majority of physicians, I think, would refuse to do willingly any reprehensible or dishonest act simply to accommodate a patient or to toady to a whim. No doctor has ever been in practice for any length of time who has not been approached and petitioned to do some act unworthy the

confidence reposed in him by the community. The consideration offered may have been small or great, but the overtures have, in the vast majority of cases, been spurned, and in language that admitted of no doubt. I have enough pride and respect for the profession to think that the exceptions in such a case are very few.

The article closes with the following remarks on myopia:

> We feel some interest, therefore, in the assertion that myopia can be improved by medical and other treatment, so that in some cases patients can get along without the glasses. * * * * But it is possible that great good might come from a more general attempt to lessen the degree of myopia before compelling the patient to put on crutches.

Now, Mr. Editor, more than a generation has elapsed since Donders made the statement that myopia is a disease, and although this assertion has been denied, the very nature of the condition, its origin, course, and transmission by inheritance of predisposition, prove the assertion to be true.

The idea of curing myopia is not new. But all measures directed toward this end must have something to recommend them besides bald and unsupported statements. Atropia has been used, operations performed, and other methods employed which, while they were very pretty, theoretically, unfortunately did not work.

We are not behind in our sense of duty. A measure which would cure myopia would be hailed with delight by every oculist in the land. But ordinary intelligence ought to teach every physician, whether oculist or not, that axial myopia, which is caused by an elongation of the optic axis, which is a striking example of a retrograde

metamorphosis, which is accompanied by all sorts of unfortunate and disastrous results, cannot be cured. Much can be done, and has been done, to lessen the tendency to the production of this affection and to arrest its progress. Alleviation, in the way of procuring better vision, can be accomplished by means of glasses, but a cure—never.

We walk along the streets of this great city and we see children with extension splints on for the cure or relief of hip-joint disease, spinal disease, and a host of other diseases, in increasing numbers daily, and we are glad. Not many years ago these poor sufferers were consigned to a life of misery and suffering and an early grave; now they walk the streets robust and hearty, enjoying life to its utmost, as only healthy children can. Instead of being alarmed at the sight of them, we rejoice that the science of medicine has achieved such a triumph.

With the same feelings of satisfaction, we oculists look at children, with joy and intelligence in their faces, who go about the streets with glasses. If those who require them, whether young or old, wear them, the possibilities of the enlightenment of the race will be increased. Very truly yours,

FRANK VAN FLEET.

158 EAST 81ST STREET.